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## UNITED STATES DEPARTMENT OF AGRICULTURE Rural Electrification Administration



# A METHOD OF DETERMINING PERFORMANCE

OF

# CENTRALIZED WATER HEATER CONTROL SYSTEMS

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OF

#### CENTRALIZED WATER HEATER CONTROL SYSTEMS

#### General

Considerable attention has been devoted to developing and verifying a simple, definitive test procedure that can be used in evaluating water heater control performance. The procedure developed is not only suitable for use by REA engineers in determining control performance, but it is also suitable for use by borrowers' personnel and manufacturers in determining performance at time of installation or at any subsequent time.

#### Test Procedure

The test procedure consists of measuring the water heater load picked up after a controlled "off" period of six to eight hours. Measurements are made by clocking the substation watthour meter disc speed with a stop watch and converting to kilowatts demand. To improve accuracy of measurement, several consecutive readings are taken immediately before and after water heater pick-up, time being allowed for regulator operation. The several readings taken are averaged to smooth out momentary load fluctuations. In order to take into account any load growth or decay during the period while readings are being taken, the "off" signal is again sent out immediately after the "on" data is taken, time again being allowed for regulator operation. The system demand is . again measured by taking the average of several consecutive stop watch readings. The water heater load pick-up is calculated by subtracting the average of the "off" readings from the average of the "on" readings. The stopwatch technique for measuring kilowatts demand is accurate well within plus or minus two percent.

# Calculation of Performance

Control performance is measured by determining the water heater load pick-up and expressing it as a percentage of the total connected load of lower elements and single elements on controlled heaters. Control performance is expressed as a percentage figure by the formula:

#### Discussion

The assumption is made that thermostats on all heaters will call for heat after a controlled "off" period of six to eight hours. This assumption has been verified by previous tests of water heater characteristics conducted by REA engineers.

A six to eight hour controlled "off" period is chosen to minimize the effect of upper elements coming into play, while insuring the operation of all lower element thermostats as well as single element heater thermostats.

It should be noted that operation of upper element thermostats during the test period will tend to produce optimistic results. Disconnected heaters not so shown in the cooperative's records and heaters turned off by consumers will tend to produce possimistic results.

Records data listing the number of controlled heaters and the element ratings must be accurate. Errors in this basic data will produce inverse errors of like magnitude in the results. Basic data errors are bound to occur because of unreported disconnects, variations in voltage on individual heaters, manufacturing tolerances in element resistance, unreported by-passing of thermostat interlocks and unreported replacement of elements of higher or lower ratings. Upper elements coming into play due to excessive water draw-down during the test period will be an appreciable factor in raising the load pick-up percentage.

Taking all factors into consideration, the results obtained from this method of determining control performance will tend to be somewhat on the optimistic side. It is possible that an actual performance figure could be considerably lower. For example, if all upper elements were to come into play during a six to eight hour "off" period, an actual performance of sixty percent would be represented by a computed performance of approximately ninety percent. Similarly, at the other extreme, an actual performance of one hundred percent of the controls would be represented by a computed performance of approximately one hundred fifty percent. Of course it is not likely that all upper elements would come into play during a six to eight hour "off" period, but certainly some upper elements thermostats do operate within this period. This is evidenced by consumer complaints that are received during a six to eight hour test period.

# Results of Field Tests

Within the past three months, this method of testing has been applied to each of fourteen substations equipped with centralized water heater control equipment. Three different manufacturers' water heater control equipments have been tested. One or two repeat tests have been made at six of these substations, making data available from 24 separate tests. The results are tabulated herewith. Extenuating circumstances account for some of the low performance figures obtained, but in general the results shown are indicative of the performance of the control systems tested.

# PERFORMANCE OF CENTRALIZED WATER HEATER CONTROL SYSTEMS AT FOURTEEN TEST LOCATIONS

		* *	Heaters	
Date of	Test	Substation	"Off"	Control Performance
Tost	Porsonnol*	Dosignation	in Hours	in Porcent '
	*		,	
8-13-54	K	1	5.00	69.0
8-16-54	P	1	5.73	68.4
9-21-54	A-K	1	5.85	79.4
8-16-54	P	2	6.07	94.2
9-22-54	A–K	2	6.00	80.6
8- 5-54	K	3	6.23	90.0
8-17-54	P	3 3	5.02	68.7
9-23-54	A-K	3	6.50	80.2
8- 5-54	K	4	7.58	120.0
8-17-54	P	4	6.43	97.5
9-23-54	A-K	4	6.73	93.3
8- 5-54	K	5	5.92	53.0
8-17-54	P		5.32	85.4
9-23-54	A-K	5 5	7.38	75.4
9- 6-54	K	6	5.97	95.5
9-24-54	A-K	6	6.48	100.0
8- 6-54	K	7	4.82	111.1
8- 6-54	K	8	6.40	101.2
8- 9-54	K	9	4.92	109.0
9-27-54	A-K	10	6.50	107.0
9-27-54	A-K	11	8.25	83.9
9-28-54	A–K	12	6.75	85.4
9-28-54	A-K	13	8.50	100.0
9-28-54	A-K	14	8.25	93.6

# \*Tost Logand:

K - Made by H. W. Kelley

P - Made by Prof. R. J. Parent, University of Wisconsin A-K - Made by John F. Atkinson and H. W. Kelley

#### Conclusions

A water heater control system that is operating in the manner intended can be expected to show a control performance figure of one hundred percent or better.

Allowing for errors in basic records data and allowing for failure of a relatively few control receivers during the interval between the final tune-up and the acceptance test, it is felt that a control performance figure of ninety percent, computed by the method described herein, represents a minimum limit for an acceptance test.

## Recommendation

It is recommended that REA's acceptance of centralized water heater control systems be contingent upon each installation meeting a control performance figure of ninety percent or better, utilizing the test method described herein.

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